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DESCRIPTION

HIGH-PRECISION SINTERED CAM LOBE MATERIAL

TECHNICAL FIELD

The present invention relates to a cam lobe part of a camshaft used in an internal combustion engine and the like and to a process for producing the cam lobe part, and, particularly, to a high-precision sintered cam lobe part which needs no grinding processing after fabricated while it has a high cam performance, and to a method of producing thereof.

BACKGROUND ART

A cam lobe of a camshaft used in an internal combustion engine and the like is slid at a high speed during running. Therefore, it is required for the cam lobe to have sliding characteristics such as wear resistance, pitting resistance and scuffing resistance.

In light of this, conventionally as the camshaft, a chill camshaft has been used which is provided with a hard white cast iron structure formed on the surface part of a cam nose by solidifying the cam nose part quickly by using a chiller during casting to improve wear resistance and scuffing resistance. Also, a camshaft which is obtained by processing a steal material by hardening and tempering treatment is used in order to improve

pitting resistance. Further, an assembly camshaft is put to practical use which is obtained by joining an iron based sintered cam lobe with a shaft to improve pitting resistance and scuffing resistance.

However, it is necessary to create a cam shape by grinding processing because the chill camshaft is a casting. Also, the assembly camshaft using a steel cast cam lobe or a liquid phase sintered cam lobe needs to have grinding processing after the assembly camshaft is fabricated since a cam lobe is inferior in dimensional accuracy. Any of these camshafts have the problem that it entails very high cost. In addition, there are current needs for cams having complex shapes such as a three-dimensional cam and concave cam, which give rise to the problem that if these shapes are formed by grinding, even higher cost is required.

It is disclosed in Japanese Patent Application Laid-Open (JP-A) No. Hei 3-291361 that a cam made of a sintered alloy which has a hardened matrix with interstitial copper and consists of 0.5 to 16% by weight of molybdenum, 1 to 20% by weight of copper, 0.1 to 1.5% by weight of carbon and, optionally, further consists of admixtures of chromium, manganese, silicon and nickel totaling at most 5% by weight, the reminder being iron, improves wear resistance and also improves the emergency running properties of a cam. However, because dimensional accuracy is not fully taken into account, it is necessary to carry out grinding process after the shaft is fabricated.

In order to make grinding processing needless after a shaft is fabricated, a method of producing a cam is disclosed in JP-A

No. Hei 8-295904, where a compact is pressed, sintered and calibrated corresponding to a desired contour, which differs from the desired contour of the cam contrary to the distortion produced during thermal refining, and then the calibrated compact is given the desired contour of the cam as a result of the distortion produced during thermal refining. However, this method has a difficulty in producing cams having complicated shapes such as the aforementioned three-dimensional cam, concave cam or the like.

Also, it is described in JP-A No. Hei 11-50210 that iron based sintered alloy parts are comprised of Cu in a weight ratio of 0.2% or more and less than 0.5%, Mo in a weight ratio of 1.0% or more and less than 2.0%, C in a weight ratio of 0.65% or more and less than 1.2% and unavoidable elements, which are balanced with Fe, wherein the dimensional change thereof is suppressed due to the contraction action of C and Mo and the expanding action of Cu during sintering. However, because generally a sintered alloy using a combination of C, Mo and Cu is decreased in Cu content and in the amount of Cu to be dissolved as a solid solution in a pearlite structure, an increase in hardness cannot be promoted, leading to a less hard product which can exhibit only insufficient wear resistance.

The present invention has been attained taking such a situation into consideration and has an object of providing a high-precision sintered cam lobe part which has high dimensional accuracy even when producing a cam lobe having a complicated shape and needs no grinding processing after fabricated while

it has high wear resistance and pitting resistance.

DISCLOSURE OF THE INVENTION

A high-precision sintered cam lobe part according to the present invention is a high-precision sintered cam lobe part obtained by subjecting a sintering powder to compression-molding and sintering one time only or two or more times repetitively to make the powder into a predetermined form and by carrying out thermal refining of the resulting body as required, wherein the cam lobe part is made of an iron-based sintered alloy comprising one or both of 0.3 to 5.0% by weight of Ni and 0.2 to 4.0% by weight of Cu, 0.5 to 1.2% by weight of C and unavoidable impurities, which is balanced with Fe, and has a density of 7.3 g/cm^3 or more, the hardness of the outer periphery of the cam lobe of 45 HRC or more and the rate of dimensional change from the molded body obtained in the final compressing process to the sintered body obtained in the final sintering process within ±0.5%.

When adjusting the final composition of the sintered body part of the sintered cam lobe part made of an iron-based sintered alloy to the above range, the wear resistance and the pitting resistance are improved due to the strength-improving and toughness-improving effects of Ni and the solid-solution hardening action of Cu and the dimensional stability during sintering can also be improved. Moreover, the wear resistance and the pitting resistance can be more improved by making the sintered body have a density of 7.3 g/cm^3 or more and by carrying

out thermal refining as required in the process of compression-molding and sintering of the sintered body.

As a result, the obtained sintered cam lobe part made of an iron-based sintered alloy ensures that the rate of dimensional change from a molded body obtained in a final compressing process to a sintered body obtained in a final sintering process can be limited within ±0.5%. This ensures that no correction by grinding processing is necessary at all or if necessary, it is only required to abrade a little, enabling a large reduction in costs. This sintered cam lobe part also ensures that the hardness of the outer periphery of the cam lobe can be made to be 45 HRC or more. Therefore, the use of this sintered cam lobe part results in the production of an assembly type camshaft superior in wear resistance and pitting resistance.

The aforementioned sintered cam lobe part is preferably a composition containing both of the aforementioned Ni and Cu. C and Ni contained in a final composition respectively have a contracting action whereas Cu has an expanding action. Therefore, in the case of using both Ni and Cu which are a component group which can be selected, a dimensional variation in the direction of the contraction and the dimensional variation in the direction of the expansion are offset to each other, making it possible to make dimensional stability very high during sintering.

It is preferable that the sintered body in the present invention further contains 0.1 to 2.5% by weight of Mo in a final composition since the wear resistance and pitting resistance thereof is more improved due to the solid-solution hardening

action of Mo.

Next, a method of producing a high-precision sintered cam lobe part according to the present invention comprises steps of: subjecting a sintered body to quench-temper treatment in which the sintered body is formed into a predetermined shape by repeating compression and sintering once or two or more times using a sintering powder prepared so as to have the following final composition; and producing a sintered cam lobe part which is made of an iron-based sintered alloy having a final composition comprising one or both of 0.3 to 5.0% by weight of Ni and 0.2 to 4.0% by weight of Cu, 0.5 to 1.2% by weight of C and unavoidable impurities, which is balanced with Fe, and in which the density is 7.3 g/cm^3 or more, the hardness of the outer periphery of the cam lobe is 45 HRC or more, and the rate of dimensional change from the molded body obtained in the final compressing process to the sintered body obtained in the final sintering process is within ±0.5%.

The hardness of the outer periphery of a cam can be made to be 45 HRC or more by carrying out quench-temper treatment for thermal refining when producing the aforementioned high-precision sintered cam lobe part of the present invention.

It is very effective to carry out the aforementioned compressing and sintering process two or more times to control the density of the sintered body to 7.3 g/cm^3 or more.

The pitting resistance can be more improved by carrying out shotblasting of the outer periphery of the cam piece after the quench-temper treatment of the sintered body to allow residual

compressive stress to generate. Therefore, this shotblasting is desirable.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing one example of an assembly type camshaft provided with a cam lobe using a high-precision sintered cam lobe part according to the present invention.

FIG. 2 is a sectional view showing one embodiment of a cam lobe using a high-precision sintered cam lobe part according to the present invention.

FIG. 3 is a schematic view of a double-cylinder contact type tester used in an example.

FIG. 4 is a graph obtained by arranging the test results of the pitting resistance of an example.

FIG. 5 is a graph obtained by arranging the test results of the wear resistance of an example.

FIG. 6 is a graph obtained by arranging the rate of dimensional change and cam lift errors in an example.

The meanings of the symbols in each figure are as follows.

Assembly type camshaft (1); Cam lobe (2); Shaft (3); Test piece (4); Opposing material (5); Lubricating oil (6); Load (7).

BEST MODE FOR CARRYING OUT THE INVENTION

A high-precision sintered cam lobe part according to the present invention is a high-precision sintered cam lobe part obtained by subjecting a sintering powder to compression-molding and sintering one time only or two or more times repetitively to make the powder into a predetermined form and by carrying out thermal refining of the resulting body as required, wherein the cam lobe part is made of an iron-based sintered alloy comprising one or both of 0.3 to 5.0% by weight of Ni and 0.2 to 4.0% by weight of Cu, 0.5 to 1.2% by weight of C and unavoidable impurities, which is balanced with Fe, and has a density of 7.3 g/cm^3 or more, the hardness of the outer periphery of the cam lobe of 45 HRC or more and the rate of dimensional change from the molded body obtained in the final compressing process to the sintered body obtained in the final sintering process within ±0.5%.

Also, a method of producing a high-precision sintered cam lobe part according to the present invention comprises steps of: subjecting a sintered body to quench-temper treatment in which the sintered body is formed into a predetermined shape by repeating compression and sintering once or two or more times using a sintering powder prepared so as to have the following final composition; and producing a sintered cam lobe part which is made of an iron-based sintered alloy having a final composition comprising one or both of 0.3 to 5.0% by weight of Ni and 0.2 to 4.0% by weight of Cu, 0.5 to 1.2% by weight of C and unavoidable impurities, which is balanced with Fe, and in which the density is 7.3 g/cm^3 or more, the hardness of the outer periphery of the cam lobe is 45 HRC or more, and the rate of dimensional change

from the molded body obtained in the final compressing process to the sintered body obtained in the final sintering process is within ±0.5%.

FIG. 1 is a perspective view showing one example of the assembly type camshaft provided with a cam lobe 2 using a high-precision sintered cam lobe part according to the present invention. FIG. 2 is a sectional view showing one example of the cam lobe 2 using the high-precision sintered cam lobe part of the present invention. The assembly type camshaft 1 is constituted of a shaft 3 made of a steel material such as a cold-drawn steel tube and a cam lobe 2 using the high-precision sintered cam lobe part according to the present invention.

The sintering powder to be used as the raw material of the cam lobe part according to the present invention is prepared such that a final composition of the sintered body (matrix), specifically, the elemental composition of the sintered body obtained after the last sintering process is finished in the case of carrying out sintering two or more times, has one or both of 0.3 to 5.0% by weight of Ni and 0.2 to 4.0% by weight of Cu, 0.5 to 1.2% by weight of C and unavoidable impurities, which is balanced with Fe. The unavoidable impurities include, besides minute impurities mingled in the raw material powder, lubricating oils such as zinc stearate added to the sintering powder and residues of other additive components.

As the sintering powder, a pure iron powder mixed with a powder of each element may be used or an alloy powder containing elements in amounts not exceeding each target percentage

composition may be used.

In the metal structure of the sintered body according to the present invention, almost or substantially all Cu is diffused in the base ground and free Cu formed of a Cu single phase is not present.

When the content of C in the final composition of the sintered body is less than 0.5% by weight, it is hard to obtain the desired hardness of the outer periphery of the cam lobe after the quench-temper treatment and the resulting cam is inferior in wear resistance, whereas when the content of C exceeds 1.2% by weight, the compressibility is significantly deteriorated, causing the density to be not raised. Therefore, the content of C is limited to 0.5 to 1.2% by weight and preferably 0.8 to 1.0% by weight.

Ni has the effect of improving strength and toughness and also serves to improve pitting resistance because it produces retained austenite which can be subject to deformation-induced martensitic transformation after the quench-temper treatment. When the amount of Ni is less than 0.3% by weight, only insufficient strength and toughness are obtained and also retained austenite is decreased, whereas when the content of Ni exceeds 5.0% by weight, retained austenite is stabilized so that it will not cause deformation-induced martensitic transformation, causing a reduction in pitting resistance on the contrary. Therefore, the content of Ni is limited to 0.3 to 5.0% by weight and preferably 0.5 to 3.0% by weight.

Cu serves to control solid-solution hardening and the

amount of dimensional variation, and C and Ni have a contracting action. The introduction of Cu having an expanding action produces the effect of controlling dimensional variation. When the content of Cu is less than 0.2% by weight, the contracting action of C and Ni prevails and the rate of dimensional change is therefore increased in the direction of the contraction, whereas when the content of Cu exceeds 4.0% by weight, this causes the rate of dimensional change to increase in the direction of the expansion on the contrary. Therefore, the content of Cu is limited to 0.2 to 4.0% by weight and preferably 0.5 to 3.0% by weight.

By controlling such that the final composition of the sintered body falls in the above range, the dimensional stability when the compression-molded body of the sintering powder is sintered can be improved and also, a sintered body superior in wear resistance and pitting resistance is obtained.

Particularly, C and Ni respectively have a contracting action whereas Cu has an expanding action when sintering. Therefore, in the case of using both Ni and Cu which are a component group which can be selected, a dimensional variation in the direction of the contraction and the dimensional variation in the direction of the expansion are offset to each other, making it possible to make dimensional stability very small during sintering without producing any adverse influence on wear resistance and pitting resistance, which is preferable.

Mo is preferably contained in the final composition of the sintered body according to the present invention. Mo improves

quenching characteristics and has the effect of solid-solution hardening. When the content of Mo is less than 0.1% by weight, only insufficient hardening effect is obtained, whereas when the content of Mo exceeds 2.5% by weight, this causes the contraction characteristics to be significantly impaired. Therefore, the content of Mo is limited to 0.1 to 2.5% by weight and preferably 0.25 to 2.0% by weight.

In the case of using Mo, it is preferable to combine at least Cu among Ni and Cu which are a component group which can be selected. Because like C and Ni, Mo has a contracting action when sintering, a dimensional change caused by Mo can be offset by combining Cu having an expanding action when sintering. It is preferable to use a combination of both of Ni and Cu and further Mo from the viewpoint of making use of all of the aforementioned effects of Ni, Cu and Mo.

The process of compression-molding the above sintering powder into a specified shape and the process of sintering the obtained compression-molded body are carried out one time only or two or more times repetitively to thereby adjust the density of the sintered body finally obtained to 7.3 g/cm^3 or more and preferably 7.4 g/cm^3 or more. It is very effective to carry out the compression and sintering processes two or more times to raise the density of the sintered body. When the density of the sintered body is less than 7.3 g/cm^3, too many pores are formed, causing insufficient wear resistance and pitting resistance. In usual, the primary temporary molding/primary sintering (primary molding and primary sintering) and the second main

molding/main sintering (secondary molding and secondary sintering) are carried out, that is, a molding process and a sintering process are carried out two times in total, whereby a sintered body having a density of 7.3 g/cm^3 or more and high dimensional precision is obtained.

In the case where a large amount of C is contained in the composition of the sintering powder, the compressibility drops and it is therefore preferable to carry out compression two or more times. In the case where the amount of C is small on the contrary, the desired sintered cam lobe can be obtained by only one compressing process.

In the compressing process, press molding is carried out using a mechanical press or the like in usual. The plane pressure at the time of compression-molding is specifically designed to be generally about 5 to 7 ton/cm^2 in the temporary molding (primary molding), namely, in the stage(s) of compression-molding excluding a final compression-molding process. Also, in the stage of the final compression-molding process (secondary molding) or in the case of carrying out compression-molding only once, the plane pressure is designed to be about 7 to 10 ton/cm^2 and is generally made to be higher than in the case of the temporary molding.

The sintering process is carried out generally using a vacuum sintering furnace or the like. Sintering temperature in the sintering process is specifically designed to be generally about 600 to 900°C in the temporary sintering (primary sintering), namely, in the stages of sintering excluding a final sintering

process. Also, in the case of the final sintering process (secondary sintering, main sintering) or in the case of carrying out sintering only once, the sintering temperature is designed to be about 1,100 to 1,200°C and preferably about 1,150 to 1,200°C and is generally made to be higher than in the case of the temporary sintering.

The sliding characteristics of the surface may be more improved by thermal refining the sintered body obtained in the final sintering process as required. Examples of the thermal refining applicable to the above sintered body include quench-temper treatment, shot blasting, nitriding (pure nitriding, carbonitriding and plasma nitriding) and infiltration or the like. Only one or two or more methods among these methods may be applied.

The hardness of the outer periphery of the cam lobe is preferably made to increase by quench-temper treatment among these methods to thereby improve wear resistance. As to the usual, procedures and conditions of the quench-temper treatment, a cam piece is heated to about 900°C in a heating furnace and then cooled quickly by oil or water to quench. Thereafter, the cam piece is reheated to about 100 to 300°C to carry out tempering.

Moreover, it is particularly preferable that the outer periphery of the quench-tempered cam be processed by shot blasting to allow residual compressive stress to develop, thereby improving pitting resistance. As to the procedures and conditions of the shot blasting in this case, usually the cam piece is rotated and a nozzle is adjusted to be able to shot the outer periphery

to treat the cam piece under a pressure of 5 kg/cm^2 by using a grit such as steel, glass beads or the like.

In the case of carrying out infiltration, an infiltrating material such as Cu or the like is infiltrated into the pores of the sintered body (matrix) of the iron-based sintered alloy by high-temperature heating, followed by cooing quickly to carry out temper treatment and the like. In this case, the composition of the sintered body (matrix) is different from the composition of the whole cam lobe obtained after the infiltration. However, the part of the sintered body must have the elemental composition of the above iron-based sintered alloy.

In the cam lobe part made of an iron-based sintered alloy and produced by carrying out the above compression-molding and sintering and further, thermal refining as required, the final composition of the sintered body part is made to have one or both of 0.3 to 5.0% by weight of Ni and 0.2 to 4.0% by weight of Cu, 0.5 to 1.2% by weight of C and unavoidable impurities, which is balanced with Fe and the sintered body is made to have a density of 7.3 g/cm^3 or more. This ensures that the rate of dimensional change from the molded body obtained in the final compressing process to the sintered body obtained in the final sintering process can be limited within ±0.5%.

The sintered cam lobe is changed in dimension not only in the stage of sintering a compression-molded body but also in thermal refining such as quench-temper treatment, shot blasting or the like after sintering. The dimensional change is largest in the sintering stage and is a little in the thermal refining

stage. Therefore, the dimensional stability during sintering is improved to limit the rate of dimensional change from the molded body obtained in the final compressing process to the sintered body obtained in the final sintering process within ±0.5%. Even if a little dimensional change is caused by the subsequent thermal refining, it is unnecessary to correct the dimension at all by grinding processing or it is only required to abrade a little. The sintered cam lobe may be used for fabricating a camshaft as it is or by carrying out processing for abrading in a very smaller amount than in a conventional case.

Unlike the case where grinding processing is made to be needless by a production method in which the cam is made into the target profile shape thereof by a strain in thermal refining as described in JP-A No. Hei 8-295904, the present invention can cope with cams having complicated forms, which have been recently increased, and also can reduce the grinding processing cost required for cams having complicated forms, which renders it possible to realize a sharp cost reduction.

Herein, the aforementioned rate of dimensional change means a maximum value among the rates of dimensional change found at each point measured as follows: using a three-dimensional measuring device, each outer periphery of the secondary molded body and the secondary sintered body are subjected to measurement in which the position of at least one point every 1° is measured over 360° and the shapes of the both which are traced from the measured points are overlapped on each other to find the rate

of dimensional change of each measured point.

Also, the cam lobe part made of an iron-based sintered alloy which is produced by the aforementioned compression-molding and sintering and further thermal refining as required is superior in dimensional stability during sintering, makes grinding processing needless and enables the hardness of the outer periphery of the cam lobe to be 45 HRC or more and preferably 50 HRC or more and therefore excellent wear resistance and pitting resistance are imparted to the cam lobe part. Particularly, when the outer periphery of the cam piece is processed by shot blasting treatment to cause a residual compressive stress, the pitting resistance of the cam lobe part can be more improved.

The cam lobe part produced in this manner is fit and secured to the predetermined position of a shaft made of a material such as S45C or the like at a predetermined angle by shrinkage fit to thereby obtain an assembly type camshaft. As a method of fitting and securing the cam lobe part to a shaft, the aforementioned shrinkage fit are preferable in view of assembly precision and low equipment cost, however, it is possible to use other methods such as press fitting, diffusion bonding or the like.

The grinding processing of the cam lobe section is unnecessary at all once the cam lobe part is fitted. Or even if necessary, it is only required to carry out processing for abrading in a very smaller amount than in a conventional case and an assembly camshaft superior in wear resistance and pitting resistance is obtained.

Examples

(Example 1)

Each element was added to an iron powder such that the componential composition of a sintered body after sintered twice was as follows: C: 1.2% by weight and Ni: 1.5% by weight which was balanced with Fe to prepare a sintering powder. Zinc stearate was added as a lubricating oil to the mixture, which was then mixed. A first press molding (primary molding) was carried out under a plane pressure of 5 to 7 ton/cm^2 to form a green compact. The resulting pressed powder is subjected to temporary sintering (primary sintering) performed at 600°C to 900°C in a vacuum sintering furnace, to obtain a temporary sintered body. Then, the temporary sintered body was subjected to a second press molding (secondary molding) performed under a plane pressure of 7 to 10 ton/cm^2 and the secondary molded body was subjected to main sintering (secondary sintering) performed at a temperature of 1,100°C to 1,200°C in a vacuum sintering furnace to obtain a secondary sintered body. The resulting secondary sintered body was subjected to quench-temper treatment and then the outer periphery of the cam piece was processed by shot blasting using a steel grit in the condition of a distance of 100 mm and an air pressure of 5 kg/cm^3, to obtain a sintered cam lobe part having the shape shown in FIG. 2.

(Examples 2 to 4)

Each element was added in an iron powder such that the componential composition of a sintered body obtained after sintered twice was the same as that shown in Table 1 to prepare a sintering powder. Sintered cam lobe parts of Examples 2 to 4 were obtained in the same manner as in Example 1 except for the above.

Table 1

Final composition of sintered body of each Example

Example No.	Final composition (wt%)							
	C	Cu	Ni	Mo	Si	Mn	Cr	Fe
Example 1	1.2	-	1.5	-	-	-	-	Balance
Example 2	0.8	1.5	-	-	-	-	-	Balance
Example 3	0.6	1.5	1.5	-	-	-	-	Balance
Example 4	0.6	1.5	2.0	0.5	-	-	-	Balance
Comparative Example 1	3.4	(Cu+Ni) 2.0		2.0	2.0	0.7	0.8	Balance
Comparative Example 2	0.8	5.0	-	-	-	-	-	Balance

(Comparative Example 1)

Each element was dissolved such that a final componential composition was as follows: T. C: 3.4% by weight, Si: 2.0% by weight, Mn: 0.7% by weight, Cr: 0.8% by weight, Mo: 2.0% by weight and Ni + Cu: 2.0% by weight. The mixture was cast into a mold equipped with a chiller and cooled quickly to coagulate, thereby obtaining a chill cast iron, which was then grinded to obtain a cam lobe part of Comparative Example 1.

(Comparative Example 2)

Each element was added in an iron powder such that the componential composition of a sintered body obtained after sintered twice was as follows: C: 0.8% by weight, Cu: 5.0% by weight and Fe: balance, to prepare a sintering powder. A sintered cam lobe part of Comparative Example 2 was obtained in the same manner as in Example 1 except for the above.

<Test condition>

(1) Density

The test piece of a cam lobe part obtained in each Example and Comparative Example was subjected to sealing treatment using paraffin to measure the density of the cam lobe part by an Archimedes method. The results of measurement are shown in Table 2.

(2) Hardness of the outer periphery of the cam lobe

The hardness of the outer periphery of the cam lobe nose of the test piece obtained in each of Examples and Comparative Examples was measured at 5 points on the C scale by using a Rockwell hardness tester and an average of the measured hardness was calculated. The results of evaluation are shown in Table 2.

Table 2

Results of measurement of density and hardness of the outer periphery of the test pieces obtained in each Example and Comparative Example

	Example				Comparative Example	
	1	2	3	4	1	2
Density g/cm^3	7.46	7.38	7.37	7.36	-	7.33
Hardness HRC	55	53	50	51	-	53

(3) Tests for pitting resistance and wear resistance

The number of pitting generation cycles of each test piece was measured by a double-cylinder contact type tester shown in FIG. 3. Each test piece 4 rotating at a constant speed was brought into contact with the rotating plane of an opposing material cylinder test piece 5 and rotated by applying a predetermined load 7 with adding dropwise a lubricating oil 6 to the contact surface between both test pieces to measure the number of cycles before a pitting occurred. Also, wear depth (μm) per fixed rotations (1×10^5) was measured.

(Measurement condition)

Measuring device: Double-cylinder contact type tester

Rotations: 1,500 rpm

Lubricating oil: Engine oil 10W30

Oil temperature: 100°C

Amount of oil: 2×10^{-4} m^3/min

Load: 1,500N, 2,000N and 2,500N

Slip rate: 0%

Opposing material: SUJ2

Method of determination: A crack when pitting was generated was detected by AE (acoustic emission) and the number of contacts at this time was put as the number of pitting generation cycles to make an S-N curve which was used to compare with each test piece.

The test results of pitting resistance are shown in FIG. 4 and the test results of wear resistance are shown in FIG. 5.

With regard to the pitting resistance and wear resistance, Examples 1 to 4 and Comparative Example 2 gave better results than Comparative Example 1.

(4) Rate of dimensional change

Using a three-dimensional measuring device, each outer periphery of the secondary molded body and the secondary sintered body were subjected to measurement in which the position of at least one point every 1° was measured over 360° and the shapes of the both which were traced from the measured points were overlapped on each other to find the rate of dimensional change of each measured point, to specify a maximum value among these measured rates as the rate of dimensional change of the secondary sintered body from the secondary molded body.

(5) Cam lift error

A test piece of the secondary sintered body after quenched and tempered and further shot-blasted was subjected to measurement

of cam lift errors. Using a cam profile measuring program ADCOLE, a cam profile was measured and compared with the object profile to detect an error between these profiles, which error was defined as the lift error.

The results of the measurements of the rate of dimensional change and cam lift error are shown in FIG. 6. FIG. 6 shows that Examples 1 to 4 in which the rate of dimensional change is within ±0.5% fulfills the specified value (0.05 mm) of the cam lift error of a general abraded product. However, Comparative Example 2 in which the rate of dimensional change exceeds ±0.5% fails to satisfy the specified value of the cam lift error of a general abraded product.

INDUSTRIAL APPLICABILITY

According to the present invention as aforementioned, the final composition and density of the iron-based sintered alloy constituting the sintered body part (matrix) are controlled and further, thermal refining is carried out as required, whereby a high-precision sintered cam lobe part which has high dimensional precision during sintering and is superior in wear resistance and pitting resistance is obtained and also an assembly cam shaft which is sharply reduced in the cost spent for grinding processing and is also superior in sliding performance and durability is obtained.

Particularly, the high-precision sintered cam lobe part according to the present invention can cope also with the case

of producing a cam lobe having a complicated shape and it is therefore possible to produce a cam lobe which quite or almost precludes the necessity of grinding processing.